INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

ANNUAL REPORT—1942

1943

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In 1942 Messrs. Comrie and Winter and Drs. Roberts, Wight and Woodford also our Tea Taster Mr. Gilchrist went away on war service. This year Messrs. Benton Harrison and Macgregor have been employed on water purification work at the I.T.A. labour camps on the various Eastern Frontier Projects. Mr. Benton had for several years been investigating the possibilities of the sliver process for the sterilization of water with the object of adapting it for use on tea estates. The process as used at the labour camps has been effective and at the same time very simple in application whilst it imparted no taint to the treated water, and thus obviated any difficulty that might have arisen in getting the labourers to drink the treated water as would have been the case if chlorination had been employed, This process has been in continuous use with very satisfactory results. Unfortunately Mr. Benton, who was far from being a fit man when he first went to the work at Dimapur, became seriously ill and had to be taken to hospital. He was however very ably assisted by Mr. Simmons of the Jorehaut Tea Coy., Ltd. This work has become much extended and a staff of not less than 6 are now controlling this work. Messrs. Harrison and Macgregor attending to the scientific side of the work and the others dealing more particularly with the new installations and the maintenance work. As regular routine a close and careful bacteriological examination of the treated water is made frequently. The unit as whole is known as the T.U. or Tocklai Unit. At the end of the year there were at work 40 installations some supplying several thousands gallons of water per diem whilst others were only required to supply a few hundred gallons.

Mr. Harrison and our Senior Assistant chemist Mr. Sen Gupta were the first to install the process on the Ledo road project. Soon

after they had commenced Mr. Harrison was called away to help the evacuation from Burma, and for his outstanding work in this connection he has recently been awarded the honour of the O.B.E.

Messrs. Deb and Dinanath Barua, assistants in the chemical branch, were sent to help Mr. Sen Gupta. Subsequently Mr. Deb was recruited to the I.A.O.C. laboratories at Cawnpore.

Mr. Tunstall and myself were the only senior officers left at Tocklai. At the request of the Military authorities Mr. Tunstall conducted a jungle lore school for training cadres. He also gave lectures at other training schools.

Owing to the war conditions and the absence on military duty of our taster Mr. Gilchrist, it has not been possible to carry out individual bush manufacture during the year. It has however been possible to nearly complete the vegetative reproduction of the bushes that had already been selected for their characteristics in the finished teas.

A field experiment has been planted with five clones prepared from bushes selected from the Betjan plot at Borbhetta. The object of the experiment is to ascertain how closely the teas from the clone plots resembles the teas from the original bush and whether the teas from the different clone plots bear the same relation to each other as do the original bushes.

Another field experiment has been planted with the object of finding how bushes raised from cuttings compare with bushes of the same jat raised from seed. It has been found that individual bushes differ greatly in the readiness with which the cuttings form roots. An experiment was carried out to ascertain whether the rooting tendency bore any relation to the character of the teas made from the bushes. Six bushes having highly desirable characters in the finished teas and six bushes having characteristics of low desirability were chosen and cuttings raised. The results shew that the cuttings from the low quality bushes formed roots more readily than the cuttings from the good bushes. The experiment also shewed a very highly significant difference in favour of the

rooting of cuttings of green wood rather than of red wood. There was however no difference in the ability to form roots whether the cuttings were taken from a mother stem or from a lateral.

The work on artificial pollination has been confined to tests for compatibility. In one case germination was as high as 79% but in the case of artificial self pollination the results were again low 24% of the bushes giving less than 10% successful germination.

It has been noticed that the characters of an individual bush could vary with the green colour of the new flush compared with the leaf colour of the older leaves of the same bush. This made it necessary to investigate the chlorophyll of the leaves, and the methods for separating the pigments. This work is in progress but is suffering much restriction from lack of workers and from difficulties in obtaining the requisite reagents. The estimation of starch in roots is also much interrupted by lack of the necessary chemicals. Further work on black rot (Corticum invisum) shewed that the fungus failed to survive on dry branches or in damp soil. On growing bushes the black rot was found to survive the cold weather on the bark as far down as 8 inches below the top pruning level.

Work has been continued on Branch Canker and Red Rust.

The possibility of using a water extract of tea waste for dyeing cotton cloth was investigated. A fast dye was obtained by mordanting the cloth with a copper salt. The colour seemed to be fast to sunlight and to soap.

At the request of the military some mechanical analyses of soil were carried out in connection with making runways at aerodromes.

The laboratory work has suffered much dislocation owing to the absence of officers upon work of military importance, and also to the occupation of Tocklai by the military. It was however realised that whilst this delay in the carrying on of experiments was regrettable yet a similar interference with the long term

field experiments would be much more serious and was to be avoided if possible. Every effort has therefore been made to maintain the field experiments.

The following list shews the more important experiments that are being maintained: —

Comparison of different methods of cultivation and the interactions with manuring severity of pruning time of pruning.

Comparison of the relative value of different forms of nitrogenous manure.

The effect upon crop and quality of different quantities of nitrogen applied as a manure.

The effect of varying the time of application of manure.

„ „ „ methods of application.

The effect of shade trees and their interaction with manures on mature and young tea.

The relative value of different kinds of shade trees.

Comparison of different jats of tea grown with and without shade and manures.

The value of prunings applied with and without additional nitrogen.

The effect of Bogamedeloa.

Comparison of different degrees severity of heavy pruning and the interaction with time of year.

Comparison of varying degrees of severity in cleaning out when top pruning.

Effect of time of year upon top pruning.

Effect of frequency of top pruning.

Effect of varying the length of new wood left at the time of top pruning.

Comparison of different methods of plucking both in regard to fineness and closeness.

Variations in the depth of planting young tea.

Manuring of young tea.

The pruning of young tea both as regard severity and time of year.

Trial of wound paints.

Effect of shade upon branch canker—sun scorch.

Defoliation as a preventitive against red spider.

We have received the returns from 41 field experiments on tea estates. I wish to take this opportunity to express my appreciation of the co-operation the Managers of the various gardens have given in continuing these experiments and in maintaining under very difficult circumstances the high degree of accuracy that is required to make the results useful.

In April the military requisitioned the General Office, the Botanical laboratory, the Guest House, and Bungalows Nos. 2 and 3.

Subsequently they also requisitioned bungalows Nos. 5 and 6. All these buildings are still retained by the military.

The rental was fixed by the Deputy Commissioner of Sibsagar and has been regularly paid.

When the Botanical laboratory was requisitioned the Botanical work was transferred to the insectary of the Entomological Branch. This gave very cramped accommodation and of course has limited the amount of work that could be done.

During the year two memoranda have been published :—

No. 14 Red Rust by A. C. Tunstall.

No. 15 Some general information on the selection and propagation of the tea plant.

The health of the station has been good and the anti-malarial measures have been effectively carried under the supervision of our Assisstant Medical Officer Dr. Sen. These control measures which have been in operation for some years have in my opinion added very materially to the efficiency of the officers of the station by keeping them free from malaria. This work requires unremitting attention if it is to be effective.

P. H. CARPENTER,

Director.

INDIAN TEA ASSOCIATION

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TOCKLAI EXPERIMENTAL STATION

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BY THE DIRECTOR, TOCKLAI EXPERIMENTAL STATION

The Senior Staff has been absent from Tocklai upon work connected with the war. Mr. Tunstall has been away at times in connection with teaching men of the fighting services jungle lore to fit them better for living in the jungles on the Indo-Burma border, which left only myself as whole time worker at Tocklai.

Messrs. C. J. Harrison and N. M. Macgregor were responsible for the purification of water for drinking purposes at the I. T. A. labour camps established on the Assam Imphal and Ledo Burma Roads etc. The noticeable absence of epidemic water borne disease in the I. T. A. camps is a clear indication of the effectiveness of the measures taken. The method adopted was the dispersion of silver in minute quantities throughout the water by passing an electric current of a few milli-amperes between two silver plates immersed in the water to be used. The water so treated was systematically tested for bacteria by means of culture plates. This process seems to have given indubitable success. Several of the Indian staff also have been employed upon war work and have been absent from Tocklai.

The buildings that were taken by the military have been retained by them, none have been made available again for our use. The earthquake in October 1943 did damage, although fortunately not to the primary structure of buildings, but much repair is needed. This has not been done as materials are difficult to obtain and then only at very exorbitant prices. Whilst the buildings are in a very unsatisfactory state yet they are all in serviceable condition, and it is intended to keep them so until more suitable conditions arise for complete repair. In the meantime it is very distressing to see Tocklai in such an unkempt state. Whilst this is so yet it has been possible to maintain the field experimental areas and the results of experiments are still available for future study. This is important and great attention has been concentrated upon this phase of the work.

The work of the various branches has been much restricted owing to the lack of directing staff, shortage of labour, inability to obtain apparatus and chemicals, in fact all those factors that have always been considered essential for progress. In spite of difficulties however I am glad to be able to report that the botanical programme has been maintained. The establishment of better types of tea bushes by breeding and selection is so important to the future of the tea industry that I regard any interference with the botanical work as serious. The rooting of cuttings taken from both green and red wood of the bush has been established in earlier experiments and it has been shewn that different bushes react differently. A further experiment using only green wood cuttings has provided data of some interest.

The bushes from which the cuttings were to be taken were pruned at different times of the year and after pruning were allowed to grow unplucked until the cuttings were taken.

A significant difference was obtained in favour of the bushes pruned in October-December, the least satisfactory time was April. The time at which the cuttings were taken from the bush was also important and the best results were obtained between April—June. The least satisfactory time was the cold weather December—February.

Using green cuttings as in this experiment there was no interaction between the time the bushes were pruned and the time of taking the cuttings. The age of the terminal growth removed, as cutting, being approximately the same in all cases.

A large number of cuttings were taken from bushes selected for the characters of the tea made with the object of establishing clones for further experiments.

A large number of hand pollinations were made in connection with the determination of compatability between bushes.

A multiclonal seed bari was established by permission of the Government of Assam in the forest reserve at Huloongapar about 17 miles from Tocklai. I wish to record my appreciation of the ready co-operation and help of the members of the Forest Department.

The Mycologist has established the correlation between a direct estimation of the starch in tea roots and the coloration of the cross section of the root by iodine, which has proved such a useful qualitative test and which now has a proximate quantitative value also. In recent years owing to the international control regulations it has not been possible to plant areas of new land, consequently old non-efficient tea has been replaced. In most cases the inefficiency has been due to disease having seriously debilitated the plants, or to the jat being inferior, or to the soil having lost its early fertility and now being reduced to the low basic level. To replant such areas means that in many cases the young plants will only obtain from the soil a very limited supply of food insufficient to meet their needs for vigorous development. The result will be that the young plants will not make the progress expected and also they will be more subject to the attack of disease. Red Rust (*Cephaleuros parasiticus*) has been noticeably prevalent.

An experiment with dark and light leaved jats of young tea has been carefully studied by the mycologist who reports that whilst potash has had no noticeable effect in controlling the red rust yet phosphoric acid has shewn a curious effect in that a small application of 30 lbs. per acre has resulted in less red rust whilst larger applications have not had the same effect. This has happened with three different jats of tea. The greatest beneficial effect has however been from the use of nitrogenous manure in restraining the development of the red rust. This effect was more apparent on the light leaved jats which is the more susceptible. Whilst the severity of attack by red rust becomes less by the use of nitrogen yet the reverse is the case with brown blight (*Glomerella Cingulata*) which is more noticeable on bushes that received nitrogen

manure. This disease however does not do such serious damage as does the red rust. In the case of this disease neither the potash nor the phosphoric acid have had any noticeable effect. The general development of the plants has however been affected by the use of all three manures.

When the plants were very young the growth of the plant shewed an increase as the amount of potash applied increased, amounting to a maximum of 1·4 maunds per acre on a crop of 5 maunds per acre when the plants were 4 years from seed, after that the effect gradually became less until the increase was no more than 0.2 maunds per acre when the plants were 7 years old on a crop of 12 maunds per acre. The use of phosphoric acid has shewn a steadily increasing result being very small at first but reaching 1.38 maunds per acre in a crop of 12 maunds per acre when the plants were 7 years old.

The use of phosphoric acid manures greatly increases the growth of weeds and if the area be not kept clean the beneficial effect of the phosphoric manure upon the tea plants is likely to be masked.

Whilst the plants when very young, 2 years old, can only use small applications of nitrogen yet at a comparatively early age they can make use of increased doses.

These results provide data, scanty though it be, for recommending the use of a complete manurial mixture for young tea. For tea in the very early years the following mixture has given good results at Tocklai-Nitrogen 20 lbs. Potash 60 lbs. Phosphoric acid 30 lbs. per acre. The nitrogen after the 4th year can with advantage be increased and the potash decreased.

The field experiments on estates throughout North East India continue to shew the importance of nitrogen and generally the absence of a practical response to potash and phosphoric acid, either singly or in combination with each other, or with nitrogen, so that it seems safe to continue with only nitrogenous manuring for mature tea, at any rate so long as the present difficulties persist in obtaining manures. The present day prices are high and it is best to spend whatever money is available upon obtaining nitrogen in a readily available and efficient form.

A Tocklai experiment that is affording results of interest is that in which 11 jats of tea are grown with and without shade and with and without nitrogen as manure. The following table shews the yield in maunds per acre of pucca tea for 1943 which can be taken as the accumulated effect of the treatments over 7 years.

	No Shade	Shade	Total
No Nitrogen	8·53	14·78	23·31
Nitrogen	14·57	17·66	32·23
	23·10	32·44	.....

The nitrogen without shade and the shade without nitrogen have given practically the same result, but the combination of the two treatments has given an increase in crop far from being the sum of the two separately. There is a marked interaction between the two treatments. Presumably the shade trees are making direct use of some of the nitrogen manure and the tea is not getting the full benefit from the application.

A very noticeable feature of this experiment is that the plots under shade, whether manured or not, are much freer from weed growth than the plots unshaded. This is a very important matter at the present time when labour is in short supply.

The results of this experiment suggest that the most efficient use of manures is obtained when they are applied to unshaded areas. This is a matter that deserves consideration, when obtaining manure in the required quantity is so difficult.

The crop increase from oil cake applied broadcast, whether buried or left on the soil surface, has no significant difference. The time of application can be at any time between October and April in order to obtain the full benefit of the manure in the following season.

Today, when adequate supervision, labour, and manure are difficult to obtain, it is necessary to give attention to using those methods that are likely to have the least ill effect, and this may apply particularly to the cutting back of mature tea that has become too high for convenient plucking. An experiment at Tocklai in which a light leaved jat, Singlo, was cut during the cold weather at different heights from the ground provides data.

The tea before cutting back was giving a crop of 9·6 maunds per acre of tea.

Pruning height from ground.	Deaths %	Crops : mds. per acre of tea.						
		1939	1940	1941	1942	1943	Total	Avg:
0″	31.6	0.34	1.85	3.01	7.36	8.64	21.20	4.23
4″	18.5	0.68	2.80	3.87	9.08	9.69	26.12	5.22
8″	11.7	1.07	3.24	4.34	9.13	9.73	27.51	5.50
12″	6.0	1.75	4.52	5.05	10.22	10.72	32.26	6.45
16″	6.9	2.08	4.68	4.93	9.92	10.08	31.69	6.34
20″	3.9	2.86	6.72	6.03	11.43	11.44	37.88	7.57
24″	2.3	3.76	7.51	6.97	12.08	11.58	41.90	8.40
28″	1.5	4.98	7.08	6.68	11.44	11.32	41·50	8.30

It will be noted how the number of deaths and the loss in crop increase with the increased severity of the pruning. The data suggest that this tea is best cut about 20—24″ above the ground. At this height the width of the bushes was largely kept which resulted in the bushes covering the ground more completely and thus greatly reducing the cultivation required to keep the ground free from weed growth.

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TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT—1944

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ANNUAL REPORT—1944

BY THE DIRECTOR, TOCKLAI EXPERIMENTAL STATION

The report for the year can be no more satisfactory than that for 1943 for the activities of the department have continued to be controlled by the conditions imposed by war. It has been impossible to initiate new experiments and it has been possible to maintain only with great difficulty the experiments in being ; especially is this so with field experiments on account of the shortage of labour.

Buildings : The buildings have been kept from deterioration but earthquake repairs have not been generally effected as materials are not only costly but very difficult to obtain. Bungalows Nos.1, 2 and 3 have however been restored and are occupied by the U. S. A. hospital staff. Bungalow No. 6 has been derequisitioned and has been occupied by Mr. Macgregor.

Delay in repairing the buildings is advisable until such time as the future plan of work for Tocklai has been defined.

Staff : Mr. Tunstall has remained with myself at Tocklai. Mr. Macgregor rejoined for normal duty on the 1st. September. Mr. Benton has remained in Darjeeling.

Mr. Harrison has continued on " Project Work ". Drs. Roberts, Wight, and Woodward and Mr. Winter are still in military employ.

Mr. Gilchrist has returned to civilian duty and it will be possible to recommence selection of tea bushes for clones on the basis of the character of the made tea. He however arrived too late for work to be undertaken in 1944.

Chemical : Further work has been attempted on the chlorophyll content of the leaf but lack of apparatus and chemicals made a continuation of this work difficult and it has been postponed for the time being. The manufacturing experiments have shewn that an increase in total nitrogen content of the leaf results in lowering of the quality of the made tea. The increase in nitrogen content of the plucked shoot is proportional (a linear function) to the increase in nitrogen supplied as manure. It is therefore of importance to study in detail the nitrogen content of the leaf. Experiments are in progress but at present are in no more than an initial stage. It is however of interest to note that the bushes within a clone show significant differences in nitrogen content. This suggests that whilst the general appearance of the bushes

seems to be identical yet differences in chemical composition occur which may effect th quality of the made tea. The matter requires study.

Standards have been given for commercial tea but it was not known whether suc standards were suitable for tea dusts.

An examination was made of 240 samples of tea dust drawn at random from co signments sent to market in Calcutta. The data allows of recommendations f standards being made.

Routine analyses of manures and soil samples were carried out. A sample quinine sulphate was submitted for examination and found to be mixed with appro imately 25% of starch.

Mycological :

An experiment on Red Rust *Cephaleuros parasiticaus* has shewn lighter plucki allowing new leaf to remain on the new year's stems during the plucking season and l resulted in improvement. Improvement in the appearance of t bush has been noticed also on a plucking experiment at Tock (Rajghur). Leaving the bushes unpruned for one year when combined in subseque years with leaving a new leaf during the plucking season seems also to have effect an improvement.

I wish to record our thanks to Messrs. The Jorehaut Tea Co., Ltd, for th co-operation in carrying out the experiment.

The replanting of areas that have long been under tea where the soils are im poverished is likely to result in considerable damage to young plants by red rust unles given lighter plucking and the proper application of sprays.

Botanical :

The establishment of clonal areas on a scale that allows of satisfactory comparison of the characteristics of the bushes so raised both in respect of cropping capacity an quality of the made tea is needed and 15,000 cuttings have been take during the year from 25 selected bushes giving an average of 60 cuttings from each individual bush. The clones finally selected will provide th reservoir of materials for raising new seed baris.

With the object of providing an improvement to the present system of raising seed bari an experiment was commenced in the Hoolungaphar Forest Reserve with multiclonal baris utilising representatives of 36 clones. Unfortunately in April military unit found the cleared areas in the forest a suitable camping grour and destroyed one of the baris. The responsibility has been acknowledged by th military authorities and compensation will be paid. But this does not overcom the delay that has been imposed upon a very important experiment. Fresh materia will have to be obtained for the replanting.

The vigour of the bushes of a clone is a factor of importance and an experiment obtain some information of this was started in 1941. The plants have now been di

and examined. The resulting data needs careful statistical study which it has not ən possible as yet to complete.

The cross pollination of selected clones has been continued and some 3100 llinations made between 19 crosses. The seed obtained will be planted and the ɔgeny examined for further elimination of undesirable clones.

Mr. Benton has during the year visited a number of tea estates in the Darjeeling ɜtrict in order to study manufacturing conditions. In co-operation with managers of Estates experiments have been carried out and it has been possible to make alterations and improvements of considerable value.

Bacteriology :

An experiment to compare plants raised by cuttings with those from seed shew no apparent difference in the general good healthy appearance of the bushes. The plants have been pruned to about 20/18 inches and will in regular plucking in the coming season.

Agriculture :

The raising of plants from cuttings is now so successful that in-filling in the ɹperimental plots is now being done with plants from cuttings taken from bushes in ɛ plots.

Experiments on estates have had to be largely discontinued although some are being ɪntinued. Our special thanks are extended to those Managers who are carrying on ɪose field experiments that have not yielded their full quota of information. The ffficulties of carrying on experiments successfully is fully appreciated. The experiɪents that have been discontinued have in the majority of cases yielded all the useful ɪformation that they are likely to give and their discontinuance would have been ffected under normal circumstances.

Some experiments have been discontinued because Managers found it impossible ɪder restricted staff conditions to ensure the accuracy of the results. We are much ɪdebted to all those who no longer are carrying on experiments for their ready coperation and it is hoped that initiation of new experiments will be possible in the not ery distant future. The experiments carried out on estates by the Managers is most ɪportant for it brings scientific and industrial thought into close association for practiɹl purposes.

The experiments with bulk organic manures have now been carried on for some time ɖ details of some of these experiments are given in the Agricultural section of this ɔort. The results clearly shew the value of the bulk organic manures and that for the ɪe application of nitrogen it is much less efficient than that of the inorganic manure ch as Sulphate of Ammonia. The efficiency compared with inorganic manure as 0% is :—

At Allynugger, the Indore Compost 43%, the Dacca compost 48%, the unfermented aterials used for making Dacca compost 68%, Animal Meal 83%. At Champarai, the ɪmpost 58%, and at Gandrapara 40%.

Whilst these data shew the low efficiency of the compost yet the commercial valu of such manures must be judged by cost of the increase in crop resulting from th manuring. This depends upon the cost of collecting the raw material and preparin the compost and varies greatly from garden to garden. This must be determined fo each and every garden. It consequently will serve no useful purpose to discuss tha aspect in this report.

The results that have been obtained from experiments on estates to determine th interaction of shade trees with manures is interesting and whilst the results so fa obtained must not be considered as final, yet at the present time when the efficien use of manures is so important owing to the shortage in supply it is thought advisab to give the results up to date, as they may help towards the better use of availab manures.

MYCOLOGICAL BRANCH REPORT FOR 1944

STEM DISEASE

BY A. C. TUNSTALL, MYCOLOGIST

Sun-scorch—Specimens of dying young plants received from time to time frequen- show the effects of sun-scorch at their collars. Such plants especially those planted the rains should have their collars protected from the August and September sun her with a bamboo chatai placed around the stem or some other device. Boga deloa planted between the lines will be helpful.

Black rot—Some bushes in spite of being treated at different times with different ray fluids such as Burgundy mixture, Perenox, etc., were affected to some extent ar after year. Although the spraying checked the progress of the disease con- lerably it does not completely eradicate the fungus from all the bushes. It was obable that the fungus was harboured somewhere on the bushes concerned. It was eady known that the fungus passed the winter season in the cracks and crevices of e tea stem but the manner of its existence was not established. As a rule such ngi live through the winter season either by forming special resting devices known sclerotia or by parasitising other hosts. With a view to discovering the resting age of the disease specimens were collected every month and carefully examined. fficient material for examination was obtained also from some affected bushes at orbhetta and at intervals from local gardens.

The fungus was traced down on the surface of the branches from the current eason's growth to varying distances between the last pruning level and the soil rface, the maximum distance was found to be 20" (almost at the soil surface). n all the cases the growth appeared to start from a hole formed on the branches. licroscopic examination of the affected current year's growth revealed the presence f the fungus in the primary bark tissue but no sclerotia were found till the 2nd eek of September. By that time the fungus invaded the whole of the primary ortex and in the tissues adjoining the cracks (formed prior to the shedding of the rimary bark) initiations of sclerotia were observed as groups of round to oval, colour- ess cells. A few isolated sclerotia about 100 across were also found in the cracks in ome places. Camera lucida drawings were made from these. The fungus, *corticium orsum*, was never found to penetrate beyond the primary bark. Microscopic examina- ion of specimens collected in the middle of October showed that the fungus enetrated the primary bark wherever it found an opening and formed sclerotia mostly in the tissues adjoining the cracks with a few in the open at the bottom of the cracks. They were not noticed on the undamaged surface of the bark. The size was always microscopic. At first they were colourless but by the middle of November some of them turned slightly darker in colour. They took the shape of the bark cells in most cases except those developing in the openings. The latter were spherical to ovoid in shape. The biggest sclerotium found measured 263 x 145

In the middle of December the sclerotia were found to be of all shapes and sizes mostly elongated and connected to one another, slightly dark coloured and with two thirds of their cells filled with a granular substance. The mycelium on the surface of the branches was slightly dark coloured and was probably dead. Wherever the mycelium happened to pass over a crack in the bark, the tissues of the primary cortex to some distance on both sides of the crack were full of scleratial bodies.

Experiments are being carried out in a neighbouring garden and at Tocklai with a view to killing the sclerotial bodies by painting the bushes thoroughly with a fungicide which penetrates readily.

Treatment of new clearances—Red rust very frequently causes considerable loss on replanted areas. The benefit of spraying young plants with ·5% Perenox in the cold weather has already been demonstrated in earlier experiments. An experiment was designed in 1941 to ascertain the effect of various treatments on tea replanted in 1935 at Katonibari Tea Estate of the Jorhat Tea Company. This was carried out with the co-operation of the Manager, Mr. L. Wilson, and Mr. N. C. Borbora, the Scientific Assistant of the Jorhat Company. 48 plots of 100 bushes each were marked out, and the greatest length and breadth of each bush recorded annually from December 1941.

Pruning—24 of the plots were pruned each year and the other 24 plots were left unpruned in December 1941.

Plucking—All plots were plucked to the janum but 12 plots in each of the above series were given additional growth by allowing a leaf to remain above the janum in July and again in August each year. Thus there were 12 groups of 4 plots of each pair of the above pruning and plucking treatments.

Spraying—One plot in each of the above mentioned groups was sprayed with ·5% Perenox in December, one in April and one in July. The remaining plot was unsprayed.

The treatments were randomised and continued until 1944. In 1944 all plots were treated alike. Plucking was to the janum throughout the season and no spraying was done. The crop was recorded in this year.

The results clearly show that leaving unpruned for one year (Dec. 1941) has increased both yield and spread. It also had a very significant effect in reducing the number of vacancies in subsequent years. The leaving of one leaf above the plucking level in July and again in August each year benefited the bushes similarly. Bushes left unpruned one year and allowed the extra growth referred to gave an increase of 14% over those having neither of these advantages.

The spread of the bushes on the sprayed plots was significantly greater than that on the unsprayed once but there was no significant difference to be attributed to the

time of the year the application was made. As July spraying requires much mo solution than December it is probable that it would be more profitable to use ·3 Perenox in December than ·3% in July. It was noticed that the plots sprayed December had significantly fewer vacancies than the unsprayed ones. It was observe that the best results from spraying were obtained in the plots that had been unprun for one year and also had the extra leaf left in July and August.

It is interesting to note that there was a very high degree of correlation betwe the spread of the bushes and the yield in the case of the pruning and plucking serie There was no significant correlation between yield and spread in the figures for th spraying series. This suggests that the spraying had altered the yield per unit are of plucking surface. This was further investigated by reducing the figures to cr per unit area. It was then seen that leaving unpruned for one year was associate with a greater crop per unit area while the leaving of the extra growth during th season tended to reduce the crop per unit area. The effect of the spraying wa inconclusive in this connection.

ADVISORY BRANCH REPORT FOR 1944

BY N. M. MACGREGOR, SENIOR ADVISORY OFFICER

Experiments on Commercial Gardens—Owing to the war many of these experiments have had to be closed down entirely while on others the plots have been plucked unmanured and a measure of the residual effect of the manures has been recorded. One or two of the more recent experiments have not been referred to in print and deserve mention here.

The Interaction between shade and inorganic nitrogen—On Rajmai and Behora experiments were carried out for 4 years in which the shade was removed from alternate blocks. In both experiments the results confirm the strong negative interaction between shade and nitrogen found at Borbhetta and referred to in last years report.

Rajmai

Shade, Mature Al. Stipulata, 40 ft. apart.

Plot yields expressed in mds. of pucca tea per acre.

	No Nitrogen	Nitrogen (SOA) @ 40 lbs. per acre	Increase from Nitrogen	
No shade	6.55	10.78	4.23	Significant increase from Nitrogen 0.66
Shade	10.93	13.41	2.48	
Increase from shade	4.38	2.63		
Significant increase from shade		1.88		

Behora

Shade Immature Al. Stipulata, 55 ft. apart.

	No Nitrogen	Nitrogen (SOA) @ 60 lbs. per acre.	Increase from Nitrogen	
No shade	7.79	14.73	6.94	Significant increase from Nitrogen 1.33
Shade	10.52	16.00	5.48	
Increase from shade	2.73	1.27		
Significant increase from shade		2.14		

In this last experiment, the shade is not so dense as at Rajmai or Borbhetta and consequently its effect is less marked. This is reflected in the small increase resulting from shade on both manured and unmanured plots and also in the little difference which shade has made to the effect of the nitrogen.

Both experiments confirm that we may expect to get about 1 maund of extra tea from 10 lbs of nitrogen on unshaded areas, and less on shaded areas according to the density of the shade.

Interaction of shade with organic nitrogen—The three experiments mentioned above deal with the interaction between shade and inorganic nitrogen but that at Behora deals also with organic nitrogen applied in the form of compost.

Behora

	No Nitrogen	Compost N at 84 lb yearly average	Increase from Nitrogen	Significant increase from Nitrogen
No shade	7.79	10.38	2.59	
Shade	10.52	11.19	0.67	1.33
Increase from shade	2.73	0.81		
Significant increase from shade		2.14		

The increase from compost on the unshaded areas, though low is not unexpected and agrees with results obtained elsewhere, but the negligible effect on the shaded areas is extremely disquieting. This result is supported by an experiment at Gingia Tea Estate where applications of eupatorium under shade have failed to give any increase, and by another experiment at Halem where cattle manure has failed on a shaded area. This failure of bulk organic manure under shade is not universal and in a second experiment at Halem similarly shaded, response to cattle manure has been recorded. The possibility however that no benefit may be derived from bulk organic manures applied to shaded areas should be constantly born in mind particularly at the present time when so much of the nitrogen applied to tea must necessarily be of an organic nature.

Potash and Phosphate. Possible Interaction with shade—The results obtained from dressings of potash and phosphate on the many N. P. K. experiments put down by Mr. Cooper have been confusing, sometimes one has proved beneficial and sometimes the other, while sometimes both give a beneficial effect when applied separately but detrimental effect when applied together. Again we may quote the Behora experiment which seems to throw some light on the question.

(Behora)

	Potash	Phosphate	Potash and Phosphate
No shade	1.24 mds. gain	0.5 mds. loss	0.89 mds. loss
Shade	0.54 „ loss	1.6 „ gain	0.16 „ gain

The significant difference is 2.30 so we may regard these figures only as indications, nevertheless the possibility that both potash and phosphate will react very differently on shaded and unshaded areas is interesting, and would certainly explain why such diverse results were obtained from the N. P. K. experiments set out as they were on shaded, unshaded and sparsely shaded areas alike.

Forms of Nitrogen and their residual effect—Most of the experiments dealing with organic forms of nitrogen have now been terminated, and call for no amendment in the findings as published in Memoranda No. 6 and No. 11, except as quoted above, namely that the effect of bulk organic manures may be so much reduced under shade as to render them almost valueless.

A very typical example of the action of organic manure compared with sulphate of ammonia on an unshaded area, is to be found in the Allynugger experiment which is recorded for the full term in the following table :—

(Allynugger). Increase of manured plots over check plots in mds. per acre.

	Inorganic mxt.	Indore Compost	Dacca Compost	Unfermented Dacca Compost	Animal meal.	Sig: effect
Mean yearly dressing of N	78	84	78	82	84 lbs	per acre
1936 no manure	0	-0.03	-0.01	0.06	0.01	0.1
1937 manured	0.60	0.06	0.21	1.01	0.96	0.5
1938 manured	1.87	0.74	0.92	1.55	2.31	0.6
1939 manured	2.26	0.86	1.04	1.61	2.77	0.6
1940 manured	3.45	1.42	1.39	2.64	3.71	0.9
1941 manured	5.28	2.36	1.90	3.20	4.48	1.05
Total increase from manuring	13.46	5.44	5.46	10.01	14.23	
1942 Nil	5.23	2.78	2.27	3.36	3.51	0.98
1943 Nil	4.08	2.23	1.96	2.78	2.36	1.00
1944 Nil	0.15	0.33	0.39	0.36	0.34	0.39
Total residual effect	9.46	5.34	5.62	6.50	6.21	

These figures illustrate :—

1. The relative efficiency of the manures under experiment.
2. The slow rise in crop brought about by annual dressings of manure.
3. The sudden drop which follows cessation of manuring, falling to an insignificant increase in the third year.
4. The failure of composting to increase the beneficial effect of bulk organic manures.
5. The residual effect of sulphate of ammonia is greater than the residual effect of organic manures, including animal meal.

The corresponding results from 2 other experiments which have been carried out to measure the residual effect of bulk organic manures are given below in the abbreviated form :—

Manured for		Increase during manured period from nitrogen as		Residual period	RESIDUAL EFFECT	
		S. O. A.	Compost		S. O. A.	Compost
Champarai	6 years	17.35	9.05	2	3.28	2.89
Gandrapara	4 years	16.68	6.14	4	6.67	3.18

INDIAN TEA ASSOCIATION

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TOCKLAI EXPERIMENTAL STATION

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TOCKLAI EXPERIMENTAL STATION

Staff.

Mr. P. H. Carpenter retired from the post of Director of the Scientific Department and handed over charge to Mr. C. J. Harrison as Chief Scientific Officer, on the 16th November. Mr. Carpenter joined the Indian Tea Association Scientific Department in 1908 when its Headquarters were at Heeleaka T. E., ten miles from the present Station. During the 1914-1918 War, Mr. Carpenter served in Iraq from 1915 to 1918. In 1919, on the retirement of Dr. Hope, Mr. Carpenter became Chief Scientific Officer and under his direction the Department developed from a comparatively small affair to a well equipped and well staffed research station in the course of 20 years.

In 1929 Mr. Carpenter was nominated to represent the Tea Industry in North and South India on the Advisory Board of the Imperial Council of Agricultural Research and continued to serve on this Board until his retirement from tea.

The war which has recently concluded seriously impaired the work of the Scientific Department. Five of its senior staff were called up for military service, four were employed for most of the war on national service, and for most of the period Mr. Carpenter had to maintain the Department single handed. I can well realise the strain imposed on him during those anxious years when in addition to the problems normal to the maintenance of a Research Station, he had to deal with the problems arising from food shortage, high labour costs, and military occupation of many of the Tocklai buildings.

His contribution to the science of tea culture has been great, and while I and my staff, European and Indian, wish him a long and happy retirement, we are aware of the loss of a great friend and counsellor.

Mr. S. F. Benton (Bacteriologist) has intimated his intention of resigning at the expiry of his present contract in November 1946.

Messrs. Harrison and Macgregor returned from home leave early in November, while Mr. Tunstall proceeded on home leave in October. Mr. Benton continued throughout the year to work on tea manufacture in Darjeeling and Messrs. Wight, Roberts, Winter and Woodford continued in military employ. Their releases are expected early in 1946, when they will take home leave before recommencing their duties with the Scientific Department.

The situation in relation to the Senior staff in 1940, and at the end of 1945 i shown below.

Name	Post held in 1940	End of 1945	Remarks
P. H. Carpenter	Director	Retired Nov. 1945	
H. R. Cooper	Deputy Director	Retired May 1940	
C. J. Harrison	1st Chemist	Chief Scientific Officer	On leave in 1945 (March-October)
A. C. Tunstall	Mycologist	Mycologist	On leave 1945-46 (November-February)
W. Wight	Botanist	Botanist	Still on Military Service
S. F. Benton	Bacteriologist	Bacteriologist	In Darjeeling 1944 to 194 Resigning Nov. 1946
E. A. H. Roberts	2nd Chemist	Tea Technologist	Still on Military Servi
L. C. Comrie	Entomologist	Died 1942	
W. Woodford	Darjeelieg Advisory Officer	Agricultural Chemist	Still on Military Servi
E. J. Winter	Surma Valley Advisory Officer	Surma Valley Adv. Officer	" " " "
F. S. Mitchell	Dooars Advisory Officer	Resigned 1942	
N. M. Macgregor	Senior Advisory Officer	Senior Advisory Officer	On leave 1945 (April-October)

The strength of the staff will thus be 5 less than the pre-war figure, at the end o 1946, when all members will have returned from Military service and home leave.

Buildings: A great deal of reconstruction and repair work is required to make good the damag caused by the 1943 earthquake, and lack of annual repairs during th past four years occasioned by the scarcity and high cost of buildin materials. Reconstruction of the administrative office and old Chemical Branch wa commenced at the end of December.

The military occupation of Tockial buildings ceased early in November, and compen sation claims for damage and loss sustained through this occupation have been sub mitted to the authorities concerned.

With the majority of the senior staff still employed on military work, or on leave, ittle beyond routine work has been possible, except in tea breeding, a separate report on which is added as an appendix to this report. This is regarded together with research on tea quality, as the most important branch of the Scientific Department's work. Both lines of work however, necessarily demand ong term programmes extending over several years, before results of a practical nature emerge. There is therefore some danger of the Industry losing sight of their practical importance, and for this reason, the Agricultural Branch undertook experiments, in conjunction with certain Tea Estates, to demonstrate the improvements which can be effected in quality of tea, its yield and uniformity. It is also necessary to investigate the incidence of disease on areas of tea planted out from vegetatively propagated material, and the influence of environmental conditions on methods used for vegetative propagation. Furthermore it is desirable to have men trained in miniature manufacture and propagation methods in localities throughout the tea districts, and to establish reservoirs of clonal material for future use in selection work. The dispersion of this work throughout the tea districts enables planters and others concerned with the tea industry to see for themselves a few of the problems involved in selection, as well as the advantages which will undoubtedly result.

Tea Breeding.

In 1941 four bushes of outstanding character were selected after tests of yielding capacity and characteristics of the tea made from 180 bushes of Betjan jat. In 1945, a further 1100 bushes were tested and of these 59 were selected. This will be reduced as a result of further tests to about 12.

The original 4 bushes have been vegetatively propagated and from the nurseries so obtained a small area of clonal bushes is now in plucking at Borbhetta. The characterstics of these four bushes are given below :—

ush lo.	Crop mds. per acre.	Valuation.	Quality.	Strength	Briskness.	Colour of liquor	Colour on Infusion	Dry Tea	Tip
2	20	1/3.0	fairly good	fairly good	good	good	bright even	Black	fair
4	36	1/8.3	fairly good	fairly good	good	fairly good	bright greenish	Black	very good
	25	1/12.2	good	fairly good	good	fairly good	bright greenish	Brownish	very good

rose scented tea, otherwise no outstanding character, poor yielder.

The study of the nitrogenous substances in the tea leaf referred to in the Annual Report for 1944, was continued in 1945, and a technical paper has been prepared for publication.

hemistry of Tea.

In addition routine work of Analysis of soils, manures, samples of tea etc. has been arried out.

Investigations on Black rot (Corticium invisum) were continued and have at last disclosed the cold weather resting stage of this fungus disease. This takes the form of Sclerotia,—groups of fungus cells, which are located inside the tissues of the outer bark of the stems, during the cold weather season. Experiments are now being carried out to find a method of destroying the disease during the cold weather resting stage.

Plant Pathology.

Tests have been made with Gammexane LG037 on white ant nests at the base of tea bushes. It is found that a nest about two feet in diameter and a foot deep, treated on three successive days with 2½ oz. injections of 1½% Gammexane LG037 in kerosene resulted in complete destruction of the white ants. Failure to kill, was the result of decreasing the strength, quantity or number of applications of the insecticide.

Climate. The rainfall for the year totalled 78·98 ins; There was good early rain but too much in May and June for a good second flush. July produced low rainfall but August, September and October were normal.

Agricultural

The total area under tea in 1945 was 86·4 acres and the crop 776 mds. tea. This gives a poor average yield of only 9 mds. per acre, but it must be remembered that many plots are unmanured, most are unshaded, and some were not plucked throughout the year.

Cessation of certain experiments. Labour shortage and cost again prevented many experiments from being carried out with pre-war efficiency. It was decided to close down entirely certain trials which were considered to have given all the information which could usefully be obtained from them. Besides which, land is required for the planting of clonal material, which will be put under new trials when it becomes mature.

The results of these experimental areas which are finally closed down are being examined, and will be published during the course of 1946. This also applies to the results of the experimental block of tea at Tulsipara in the Dooars, which was closed down at the end of 1945.

I would like here to extend my grateful thanks to Messrs. Duncan Bros. & Co., Ltd. and their Managers and Assistants who have been concerned in these experiments, for the great help they have given in making these experiments the success they have been, and also for their kindness and hospitality shown to me and my staff on the occasions of our visits to the experimental plots. Mr. P. K. Chakravarti, who has been in charge of the plots since 1934 has worked with great ability in maintaining a high standard of work from the labour, and in keeping accurate records.

Shade Experiments. In our experiments on manuring, pruning, and other cultural factors, it has generally been necessary to use areas of tea entirely devoid of shade

ne of the chief reasons for this is that shade trees normally grow unevenly, and one the first essentials in experimental plots, is evenness.

It has however been recognised for a long time that the shade tree is essential to e maintenance of first class tea in a great many districts. Although heavy manuring ill maintain high crops with no shade, there are times, such as slumps and wars, hen manure supplies either become regarded as expensive luxuries, or are obtainable ily in small quantities and at high cost. There are times when the shade tree comes an insurance against inadequate manuring, and it is on the whole wisest to aintain shade even at the expense of some loss of quality in the teas.

Bearing this in mind the Department laid out trials to determine the effect of shade n yield and quality. The first experiment was started on newly planted tea in 1936. n this experiment the tea consists of a variety—well known jats, twelve in number of oth dark and light leaf. Some are manured and some not manured. Half the plots re not shaded, and half have Sau (Siris) planted 40ft. apart.

In 1945, its ninth year from planting, the yields were as follows :—

Manuring	Maunds made tea per acre		
	No shade	Shade	Mean increase due to shade
No manure	7·2	14·1	6·9
30 lbs. nitrogen per acre (300 lbs. Sulphate of ammonia)	12·2	16·8	4·6
Mean increase due to manuring with 60 lbs, nitrogen	5·0	2·7	

Previously (when the tea and shade were 5 or 6 years old) the increase due to shade was just about the same as that due to 30 lbs. nitrogen as applied manure; now, as both tea and shade mature the shade is worth more in crop return, than 60 lbs. nitrogen.

The yields from this area are perhaps a little disappointing as a whole for tea in its 9th year, but it must be remembered that these yields are averages of several jats, some of which have proved most disappointing. While the yield from the best jat is 20.3 mds., the poorest is giving only 13.6 mds., both jats manured and under shade.

In another experiment, in this case light leaf tea planted in October 1939, there are 7 different varieties of shade trees. In 1945 its 6th year from planting, this area gave an average of over 17 mds. per acre unpruned. Variety of shade tree, whether

eguminous like Sau (black Siris) or non-leguminous, like Tung (A. Montana), has so ar made no significant difference to crop, or to appearance of the tea. On this area also a trial of potash and phosphate manures shows no effect on yield from either mineral. In the intensive culture of tea, when yields in the neighbourhood of 20 mds. per acre are taken off annually, the question of potash or phosphate deficiency becomes of importance. Shade trees normally have a limited span of existence before they succumb to Canker and have to be removed. The wood, totalling many tons per acre, which has to be carted off the area, inevitably removes considerable quantities of the two minerals, and sooner or later replacement of these latter must be made in the form of manures.

Tea Seedlings versus Cuttings. Some doubt was felt regarding the growth into mature tea bushes, of vegetatively propagated "tea cuttings", compared with the normal seedling grown from a tea seed. In 1942 an area was put out in plots, half of which were planted with one year old seedlings of a certain jat, and the other half with one year old cuttings from the same jat of plants. In 1945 there was no appreciable difference in appearance and yield between the plots of seedlings and those of cuttings.

Plucking experiments. It has been an accepted fact for many years, and is supported by experimental results, that if any change is made in the method of plucking which results in more leaf being left on the bush, the immediate effect is loss in crop. If any change is made towards closer plucking a larger crop is the immediate result.

Thus, an unshaded area of good young tea plucked at 8" and to the janam for some years, was divided into plots plucked at various levels from 4" to the janam, up 8" and a leaf. The year before the change in plucking was made, the area gave 13.3 mds. tea per acre. For the first few years the closer plucking viz. 4" and 6" to the janam gave substantial increases over 8" to the janam, while the lighter plucking lost crop. In 1945 however, all yields are the same, and stand at about the same level as in the year before the experiment when all plots were plucked to 8". The close plucked tea looks very poor compared with the lighter plucked and it is expected that the yield of the former will drop considerably behind the latter in future years. Even if it does not, the fact that, excepting for inital losses, the same crop will ultimately be given whether the plucking be to 6 or 8 inches of new wood is of the utmost importance in garden practice.

From every point of view a lightly plucked section is more easy and cheaper to maintain in condition than is a close plucked section. Cultivation is reduced to a minimum owing to better spread of the bushes, pruning is straight forward, and absence of diseases such as red rust and violet root rot, which are symptomatic of debility, are absent on the light plucked tea.

The burial of oilcake and green jungle. Two experiments started in 1941 dea with the desirability of hoeing in manure after application. It had previously beer established that nothing is to be gained by hoeing in Sulphate of ammonia, but with

organic manures it was supposed that the burial of the manure was necessary to prevent loss of nitrogen in the form of ammonia given off from the rotting oilcake or jungle.

Two experiments were set out to examine the subject and the results show conclusively that the loss of nitrogen when the manures are not hoed in, is insufficient to alter the crop.

Bacteriological.

Mr. Benton, the Bacteriologist, continued to carry out experiments on manufacture of tea in the Darjeeling district throughout 1945. Striking results have been obtained as a result of modifications in the various processes, particularly in rolling and firing. These results will be communicated in a separate memorandum which is in process of preparation.

APPENDIX

Report on the position of the Tea Breeding Programme on Nov. 15 : 1945.

(1) It is estimated that conditions during the years 1940-1945 inclusive have resulted in the total loss of two years breeding work. This is irrecoverable loss on breeding work alone. Pure research has suffered more heavily, but it is gratifying to record this relatively light loss in practical results.

(2) With effect from Nov. 15th. 1945 it is possible for breeding work to proceed at pre war tempo (but see para. 69 below).

(3) Due to war conditions many breeding schemes have not been started as soon as was anticipated. The nature of these schemes is outlined in paras. (17) to (26) below.

(4) Those schemes which have been started have progressed in reasonably good accordance with the target dates as laid down in the breeding programme. In this connection great credit is due to the Assistant Botanist who has persisted with the original schedule in the face of many difficulties and for much of the time in the complete absence of competent botanical advice.

(5) The greatest disappointment has been the failure to foresee the need for increasing the number of seed bearing grafts (table III refers) and the failure to build up standard clones of all of the parents used in breeding (table II refers). This has resulted in an avoidable loss of two years work.

(6) Following the visit of the Botanist on War Leave from Iraq in April 1944 the breeding programme was speeded up so that more schemes are now in progress than was originally planned. Although many of these have been started late and are therefore behindhand, the increased number of schemes will eventually compensate for the lessened progress to date.

(7) According to the original programme the F1 offspring (see sub para. 20c) of one complete scheme were to be ready for trial each year commencing with 1946. By 1950 the offspring of five schemes were to have been tried. Now the first complete scheme will be ready for trial in 1947. Numbers of F1 offspring will become ready for trial each year thereafter. But owing to lack of seed bearing material no schemes, with the exception of Japvo, will be entirely complete until 1951, and the whole programme will not be back to target dates—*i.e.* lost time will not be made up—until 1952. The situation is given in detail in table II.

(8) Ten *line breeding* schemes are now in hand as against six originally planned to date. The object of each scheme is the production of a new variety.

(9) One of these schemes is only one year behind the target stage of progress for 1945. This is the JAPVO scheme (see table II). In this case it is possible to examine a new variety growing in the field, the plants of which are four years old. The results are encouraging and confirm that distinct improvements in uniformity over existing commercial *jats* are relatively easily obtainable at Tocklai. Manufacturing trials will begin in 1947. It is not proposed to distribute the variety in its present stage as further improvements in uniformity are likely to follow very rapidly.

(10) In addition to the line breeding schemes, *mass selection* schemes drawn up in 1940 are also in hand. These are four in number. They were started in 1943, a year later than was projected. Due to shortage of labour for maintaining the baries, which are isolated in heavy forest, growth of the plants has been retarded so that they are approximately one year behindhand, thus making a loss on these schemes of two years. In addition, one bari was completely destroyed by the military. This will be replanted in early 1946. Each of these baries is approximately one acre in extent. Seed from the three remaining baries will be available for planting in the trial plots in Nov.-Dec. 1946.

11) Progress on the mass selection schemes is entirely due to the work of Mrs. Wight and the Assistant Botanist during the years 1940-1943. The isolation of these baries under ideal conditions in a forest reserve has been possible through the courtesy and co-operation of the Forest Dept.

GENERAL PROBLEMS.

12) Any tea plant is infertile with its own pollen so that the tea of commerce is completely hybridised and excessively variable. This variability extends not only to external characteristics and adaptability to soil and climate, but also to the yield and manufacturing characteristics such as flavour and strength, which affect the marketable value of the tea. As all tea plants are of hybrid origin and as each tea plant must be fertilised with pollen from another plant, progeny grown from seed are necessarily mixed unless the plants which produce the seed have been selected by an expert. This selection necessitates many years of preliminary investigation.

13) The seed bearing trees in a tea seed *bari* are normally grown from seed; thus each seed bearer is genetically different from its neighbours, and as pollen is distributed at random by bees and wasps, the number of possible crosses in a seed *bari* of, say 20 acres, with 100 trees to the acre, is immense. In these circumstances uniform progeny are impossible. In the past no scientific tests were made of any of the plants which went to form the *bari*. By limiting the number of trees the number of crosses is reduced, and the scientific line

of attack on the problem is to establish CLONAL seed baries consisting of not less than two clones: this is because a clone enables one to obtain an indefinite number of identical plants.

(14) A clone is an indefinite extension of the plant body, and is obtained by VEGETATIVE PROPAGATION as opposed to propagation by seed. Small pieces of the stems of one chosen plant are taken and are induced to form roots, and eventually, to form a new plant. This process can be continued indefinitely. Each of these new plants is part of the original plant body and is identical with it in all respects. The variation which may be incidental on propagation by seed is thus circumvented. This indefinite extension of a plant body is known as a clone.

(15) It will be seen that a tea seed bari composed of one clone would not produce seed, as all the plants in the bari would be identical and tea is infertile with its own pollen. Two clones, suitably interplanted, would suffice, provided that they are interfertile. Unfortunately, various degrees of COMPATIBILITY exist between tea plants, such that pollen of "A" may or may not be suitable for "B". This factor has also to be investigated by the expert in charge of the selection. It is known however, that nine clones taken without regard to the compatibility factor will give a normal crop of seed. With a lesser number of clones a preliminary inspection of their compatibility is necessary to ensure a normal crop of seed. With only two clones it will be seen that there is likely to be minimal variation in the resultant crop of seed.

(16) The current line of attack on these problems at Tocklai is—

(*a*) Original selection of parent plants. This usually necessitates the manufacture of leaf from individual bushes by means of apparatus specially designed to deal with small quantities of leaf. The services of an experienced tea taster used to this kind of work are also necessary. The yield must be measured, as poor croppers are obviously undesirable. The aim of this selection is to pick out first class bushes as a basis for subsequent work. As the quality of the tea leaf varies at different times of the year, this has to be allowed for, and the minimal period for these tests is twelve months. In the initial stages of the work it had to be established that the variation in quality from year to year would not materially influence selection based on so short a period as twelve months.

(*b*) Breeding from the selected material. This is described below.

METHOD OF BREEDING.

(17) A simple way of understanding the problems involved in tea breeding is to regard the process as analagous to animal breeding in which two parents are

always necessary. On this conception two parental clones are required in a seed bari : one of these can be considered as the male and the other as the female, depending on which is giving and which is receiving the pollen.

(18) The production of these parents is the object of line breeding, which in our case starts with two parents possessing desirable characters but whose breeding capacity is unknown, and aims at selecting from their descendents two parents which will breed true to type. These two parents eventually make the two clones for the seed bari.

(19) Continued breeding from the offspring of any one cross—that is continued breeding from an initial pair of parents—results in a family tree which is intended to culminate in a new variety. This is what is meant by *line breeding* the aim of which is to produce a variety which originates from a single pair of parents only.

(20) In the family tree arising from the initial pair of parents, three branches in the line of descent become possible after the offspring have been obtained from the first mating

(*a*) By back crosses of the progeny to one of the initial parent plants. If this plant is considered to be the male, the back cross would be a *father* × *daughter* mating. The resultant line of descent obtained by repeated back crosses to the original male parent would be analagous to the male line of descent in a similar system of animal breeding.

(*b*) By back crosses of the same progeny to the other parent. Continuing the analogy, this would be regarded as a *mother* × *son* mating. The resultant line of descent obtained by repeated back crosses to the original female parent would be analagous to the female line of descent in a similar system of animal breeding.

(*c*) Using the same analogy, successive *brother* × *sister* matings are possible, giving a line of descent in which the F1 (first filial), F2 (second filial), F3 (third filial) and successive generations are directly descended one from the other.

(21) According to the exigences of the scheme, crosses between the above separately considered lines of descent may be made. Amongst other factors, the need for making such crosses would be determined by the need for counteracting any loss of vigour which might be induced by continued inbreeding down one line of descent.

(22) There are several reasons against commencing a tea breeding scheme with only one pair of parents. More than one pair of parents desirable for achieving the set object can be chosen. Each pair of parents will be likely to give rise to two

individuals which could be selected as the progenitors of the new variety There will be a line of descent from each pair of parents, and the best line ca eventually be retained and those which are more unsatisfactory discarded.

(23) In the technique of breeding, each line of descent can give a three branche family tree as described in para. (20).

(24) Most of the line breeding schemes at Tocklai have been started with thre desirable plants A, B, C. These three individuals give three possible pairs c parents AB, AC, BC, the lines of descent from each of which is investigate This is shown in table I.

(25) With an initial choice of two desirable plants only one line of descent possible *viz.* A x B. With an initial choice of three desirable plants thre lines of descent are possible *viz.* A x B, A x C, B x C. Four plants give si possible pairs of parents with six lines of descent to be investigated. In gener *n* plants give $\frac{n^2-n}{2}$ possible pairs of parents. It will be seen that the numbe of possible matings rise very rapidly with a slight increase in the number c plants selected with which to begin a scheme.

(26) It is not essential to make every possible mating amongst a number of desirabl plants selected as suitable for inclusion in one scheme. With many desirabl plants selected to begin a scheme, time and labour prevent all possible mating being made. Some choice has to be exercised amongst the possibilities. Th is illustrated by the details given for the Deopathar scheme in Table Generally, the current schemes start with three plants, all possible mating being made in the first stage of the scheme.

LINE BREEDING at TOCKLAI.

(27) The main breeding programme at Tocklai is based upon this method of advanc It is directed towards the production of bi-parental baries *i.e.*, bi-clonal barie Work along these lines allows for the improvement of the variety ad-infinitum But an appreciable time must elapse before large scale production of seed i possible.

(28) Breeding down the lines of descent in any one of these schemes will cease either

(*a*) When the variety is considered satisfactory from the point of view c uniformity, vigour and manufacturing characters.

(*b*) Or when it is considered that the production of satisfactory results is no worth the time and expense involed in pursuing the particular scheme.

29) In the latter case the scheme would be abandoned in favour of another potential variety derived from other parents. The elimination of unsatisfactory schemes is covered by provision for the initiation of a regular succession of new schemes (see para. 39).

30) It is possible that in some cases the offspring of the initial pair of parents will be satisfactory. In this case no further breeding would be necessary and clones from the initial parents would be the producers of the new variety.

31) It will thus be seen from para (38) that with extraordinary good luck it might be possible to distribute a new variety at the end of the seventh year after commencing a scheme. Our current time table is based on fifteen years work on each scheme.

32) Ten line breeding schemes are now in hand, each of which aims at producing a new variety. Each scheme is known by a name such as JAPVO which can be used as the interim name of the new variety. The names provide a designation by which unqualified field staff can easily remember the location of particular plots of plants in the field. The use of numbers alone has been found unsatisfactory. The series of names in use is taken from the mountain ranges on the NW, N and NE frontiers of India. The names are impersonal, indigenous and avoid confusion with existing *jat* names.

MASS SELECTION AT TOCKLAI.

33) An alternative to line breeding is mass selection, whereby many similar parents are chosen and allowed to breed indiscriminately amongst themselves. Some degree of mass selection is practised in the better commercial seed baries, but the number of parents in the bari is far too large. The main failings of commercial concerns are

(*a*) That few Managers understand criteria of selection.

(*b*) There is no limit imposed on the number of parent plants in the bari.

If the number of parents are cut down and the deficit in individual plants made up by vegetative propagation, considerable improvements should be possible.

34) The Tocklai mass selection schemes presuppose the production of varieties which are an improvement over existing commercial *jats*, but do not anticipate such a high degree of improvement as is possible with line breeding. Improvements ad-infinitum are not possibly by the sole pursuit of mass selection. The results from the Tocklai schemes are therefore expected to be of less permanent value than those from line breeding. They can however be obtained more quickly. Parent clones which are proved satisfactory can be made available

for distribution in the first place 4.5 times more quickly than those from lin breeding.

(35) Work on four baries, each consisting of nine clones, was commenced in 194 (see para. 10). One was destroyed by the Military. Seed from the remainin three baries is expected for trial in 1946.

(36) Modifications of mass selection whereby Managers themselves will be able t improve existing small seed baries for the production of their own seed wer contemplated before the war and will be put into operation as soon as possible One commercial concern has been using these methods since 1938, though i is understood that the criteria of selection is leaf form alone.

CLONAL GARDENS.

(37) Ordinary tea garden extensions consisting of mono-clonal material have beer visualised by the Agric. Branch. Work along these lines has been proceedin during the absence of the Botanist. This possibility is borne in mind, thoug the danger of the total loss of a garden so planted, through the incidence o disease, cannot be too strongly emphasised. Many years' experience with th clone would be necessary before such extensions could be generally recom mended. A drawback of the method is the big time lag inevitable in buildin up an initial clone sufficiently large to provide the necessary material.

TIME SCALE.

(38) The minimal time scale for line breeding is as follows:—

Seed bearing grafts established	...	Year Y
FI seed produced	...	„ Y+2
Trial manufacture	...	„ Y+6
First back cross	...	„ Y+6

Shortage of material and staff may easily extend this by two to three year In the beginning, methods and sources of material have to be investigate Then the parents for grafting have to be selected. All this involves a initial non recurring time lag which cannot well be less than two year Tea breeding at Tocklai began in 1936. Due to various practical difficu ties encountered in the early stages of the work, cut and dried scheme did not commence until 1939. In view of the delays subsequent to th Botanist proceeding on military service it has been decided to dat progress with reference to the year 1940.

39) Our aim is to commence one new scheme per year—

(*a*) Approx. half of these potential new varieties should be worth trial under the supervision of the District Officers.

(*b*) Half of the new varieties tried should be worth distributing.

(*c*) This means one new variety every four years.

(*d*) On the basis of replanting every 20 years, a Manager should thus have five new varieties to choose from, one of which is likely to be suited to his particular conditions.

40) The invention of a suitable machine by Mr. Pizey of Messrs. McLeod & Co. has overcome the need for hand manufacture. Mechanical means of rolling small samples are available such that

(*a*) A greatly increased number of repeats can be done at once, thus enabling a bigger range of material to be examined for possible parents.

(*b*) Smaller trial plots of F1 progeny can be used in an earlier stage of growth.

The above time scale (para. 38) takes these factors into account.

PROPAGATION.

41) Propagation work was transferred trom the Mycological to the Botanical Branch in 1938. Material results to date are indicated in the foregoing paras. Our conclusions regarding principle are given in paras. (43) to (57) below.

42) Current and incomplete work aims at finding the best methods of packing and the best stage of growth for distributing large quantities of clonal material to any given location in India. To usefully apply the results of the breeding programme the distribution of vegetative material must be made comparable in simplicity and success with the distribution of seed.

CUTTINGS.

43) More than 70% of all tea gives over 60% rooting. Thus the question of whether or not a plant will root well is not of very material importance in selection. Work may proceed on the assumption that most of the material selected will give a sufficiently good degree of rooting, and obstinate cases encountered may be dealt with separately.

44) The above statement includes a normal percentage of plants showing the *zig-zag* character. This character is known to be associated with poor rooting and also

with pathological symptoms such as "rim blight" and die—back. The elimination of the *zig-zag* character is therefore necessary at an early stage of selection. The *zig-zag* character seems to be the chief trouble in the poor rooting of some of the lighter leaf types.

(45) The relation between potash content and rooting capacity has been examined. A low degree of correlation was found which is not likely to be of any practical value in selection. The investigation however, produced a considerable amount of data which will be of value in furthering our knowledge of type varieties of the tea plant.

(46) Individual plants show significant differences in the ability to form roots upon cuttings.

(47) The ability of tea plants to form roots upon cuttings is significantly related to the parental origin of the plants. Rooting capacity is therefore a heritable character.

(48) The "colour" (greenness) of the leaf is significantly related to rooting capacity.

(49) The presence of the *zig-zag* character is significantly associated with poor rooting.

(50) Indole B acetic acid was found to have a slightly beneficial effect at a low degree of significance, on the percentage of cuttings to form roots. Roots on the treated cuttings were larger and better but no quantitative estimate was made of this factor.

(51) Time of the year at which the cuttings are taken has a significant effect on success. The effect of time of the year is independent of the age of the cutting used. April and June were found to be the best months. May cuttings were not investigated, but by inference, April, May and June are the best months. These results require aligning with conflicting reports from garden managers.

BUD GRAFTS.

(52) Detailed knowledge based on experiments is lacking, but the field technique has reached a satisfactory stage of proficiency.

(53) Stock—scion compatibility exists in tea.

(54) The factors influencing a successful union seem to reside more particularly in the stock : "compatibility" does not seem to be an equally reciprocal relation.

(55) The parentage of stocks raised from seed is important. Even though such stocks vary individually, a certain percentage serve to confer either a common "goodness" or a common "badness".

(56) The nature of the distribution of stock-scion compatibility is not likely to materially influence any desired programme of propagation. Clonal rootstock is not likely to be necessary for the generality of unions. Provided that a suitable source of seed for rootstock material is chosen, then grafting may proceed on the assumption that the majority of the bud types will give a sufficiently high percentage of unions. Individual cases of difficulty would be dealt with as they occur. The probability of difficulty arising with rootstocks raised from seed is not sufficiently great to merit a-priori consideration, provided that the stocks are raised from suitable parents.

(57) Other considerations, such as dwarfing effect, possible effect on quality, etc., are not of material importance in our present line of work. It is to be noted that this aspect leads into a sea of difficulties, which, in the case of apple, have been solved by devoting the activities, of an entire research station to these problems alone for a period of something like twenty years.

CLASSIFICATION

(58) The classification of properly recognised varieties of tea is of prime importance. Outside Russia no satisfactory system has been evolved. We have inadequate knowledge of the details of the Russian work, but so far as can be seen our conclusions are in agreement with the main conclusions of the Russian work so far available.

9) Liaison with the Russian research workers would be of mutual advantage, particularly if exchange visits could be arranged.

0) By 1939 the Botanist was able to recognise and classify certain main or key types of tea plant. The Quarterly Report for June 1939 refers.

1) The classification and relationship of the types recognised by the Botanist was described in the abovementioned report, but no description of the types was given. It was planned to make these descriptions in 1940. Due to the Botanist proceeding on military service in late 1940, the whole of his available time in early 1940 was spent in organising the propagation and breeding work with a view to its continuance during his absence. Subsequent events have justified this policy.

2) The position with regard to classification now is that the only descriptions of the types isolated are the actual plants themselves growing in the Tocklai plots.

) One of the first duties of the Botanist on his return to the Station should be the Botanical description of the type plants isolated by him in the Tocklai plot.

The exact nature of the diagnostic characters used are at present known only to the Botanist.

(64) The importance of establishing clones from plants representative of botanical types cannot be too strongly emphasised. There is no permanency attached to the varieties of the seed merchant, nor to those visualised in the Tocklai breeding schemes, which allow for continual change in connection with continual improvement. The value of basing recondite research on such ephemeral "standards" might well be questioned. Furthermore, each variety is evolved to supply a specific need, quite independently of our conceptipn of graded and standard series of all the types of plant possible; and the only enduring meaning which can be attached to any particular variety is by referring it to a series of recognised botanical types. Adequate supplies of clonal material of recognised types might well make the best basis for most routine field and factory experiments. Recent work by the Chemical Branch on the nitrogen content of standard types selected by the Botanist support this contention.

(65) It is planned to resume the study of these types in 1947 after the return of the Botanist from Home Leave. Clonal material could be made available in the following year.

(66) Dr. Wight has recently discussed the classifiction of tea with Capt. Kingdon Ward, the noted Botanist and explorer, who has a life time experience of the N. E. Frontier. Capt. Kingdon Ward is definitely interested in the further investigation of the geographical home of tea in collaboration with Dr. Wight. It is pointed out that as far as can be ascertained, the tea of commerce has been derived from relatively few sources and the potentialities of material existing wild in nature has not been properly investigated.

B. P. W.—24-5-46—1430